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**PROGRAM and ABSTRACTS  
of PAPERS  
CITRUS RESEARCH CONFERENCE**

**December 5, 1972**

**FRUIT and VEGETABLE CHEMISTRY LABORATORY  
263 South Chester Avenue, Pasadena California 91106**

Western Region, Southern California : Hawaii Area  
Agricultural Research Service UNITED STATES DEPARTMENT OF AGRICULTURE



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FOREWARD

This Citrus Research Conference is being held to bring to members of the citrus and allied industries in Southern California and Arizona the latest results of research on the chemistry, pharmacology, and technology of citrus fruits and their products carried on by the Agricultural Research Service, U.S. Department of Agriculture. The following are participating in this year's conference.

Western Region

Fruit and Vegetable Chemistry Laboratory  
263 South Chester Avenue, Pasadena, Calif. 91106

Western Regional Research Laboratory  
Berkeley, Calif. 94710

Southern Region

Citrus and Subtropical Products Laboratory  
600 Avenue S, N.W., Winter Haven, Florida 33882

Food Crops Utilization Research Laboratory  
P.O. Box 388, Weslaco, Texas 78596

Conference headquarters: Huntington-Sheraton Hotel 1401 South Oak Knoll Ave. Pasadena, California
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## P R O G R A M

## CITRUS RESEARCH CONFERENCE

Tuesday, December 5, 1972

MORNING SESSION - 9:00 A.M.Abstract  
on page

WELCOME: *Vincent P. Maier, Chief, Fruit and Vegetable Chemistry Laboratory, Pasadena, California*

INTRODUCTORY REMARKS: *Robert L. Olson, Assistant Deputy Administrator, Western Region, ARS/USDA, Berkeley, California*

CHAIRMAN: *P. H. van Schaik, Assistant Research Area Director, Southern California-Hawaii Area, Western Region, ARS/USDA, Riverside, California*

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aSB369

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1968b

Citrus Research Conference, Pasadena,  
Calif., 1968.

Program and abstracts of papers.  
Pasadena, Western Utilization Research  
and Development Division, Agricultural  
Research Service [1969?]

23 p. illus.

(11) 1. Citrus. Congresses. I. U.S.  
Agricultural Research Service. Western  
Utilization Research and Development  
Division. II. Title.

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LEMON JUICE CLOUD, PARTICLE SIZE DISTRIBUTIONS  
AND RELATED PROPERTIES\*

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Fruit and Vegetable Chemistry Laboratory  
Pasadena, California

Lemon juice is turbid because of its particle content. These particles are often referred to as cloud. Their properties are incompletely understood and the work to be described is part of an effort to characterize them. An electrical sensing method has been used to examine particle size distributions. Because of the extensive role played by this method, its principal aspects will be described in some detail. A technique that has been useful in quantitating juice cloudiness will also be discussed.

A Model A, Coulter Counter was used to estimate particle size. In operation, this counter applies an electrical potential across an aperture. While the potential is being applied, the counter drives an aliquot of particle suspension through the aperture. As a particle starts to traverse the aperture, it raises the effective electrical resistance. Thus, during the passage of the particle there is a drop in the electrical current through the aperture; this drop constitutes a pulse. Since the magnitude of the resistance change increases with increasing particle size, pulse magnitude and particle size are related. By counting pulses as a function of their magnitude an estimate of particle size distribution is obtained. The counting of pulses that exceed a series of operator-selected magnitudes, or thresholds, is central in the electrical sensing method.

Several particles can be in the sensing zone of the counter at one time. This occurrence is referred to as coincidence, and appropriate corrections may be made for it if the particle counts are held below a suitably chosen limit. It is chiefly because of the need to allow for coincidence that juice specimens must be diluted for counting. In the present work, diluent was prepared from 0.125 M NaCl containing one gram per liter of  $\text{Na}_2\text{SO}_3$ ; this solution was filtered and boiled shortly before use.

Size calibration of the counter has been based upon latex particles of known size. Manometer calibration was restricted to evaluation of the ratios of the three volumes provided by the manufacturer. The largest manometer volume was assumed to equal its nominal value of 2000  $\mu\text{l}$ .

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\*This research was supported in part by the Lemon Products Technical Committee, Los Angeles, California.

Size distributions were sampled at 23 preassigned particle diameters that increased logarithmically from 0.80 to 55.0  $\mu\text{m}$ . To help in comparing juice particle distributions, a cubic curve was fitted to each set of data. This curve-fitting procedure was useful, because it readily provided non-subjective estimates of such characteristics of a particle system as modal diameter and distribution width.

The technique for evaluating turbidity was developed to facilitate comparison of juice cloudiness within the laboratory. Instead of a "standard" suspension, the present method employs a reference optical absorbance which is closely bracketed with quantitatively diluted juice specimens. The absorbances thus found are used to estimate the dilution needed to yield precisely the reference absorbance of 0.5. A dilution factor found in this way is referred to in the present work as a turbidity index value.

Fresh juice samples are readied for examination by first straining out most of the coarse solids with cheesecloth, and then filtering through a sintered glass frit of EC-porosity. These preparative steps have not altered juice turbidity in any readily discernable way. Samples of lemon juice concentrate that have been examined have not required filtration.

An extended study of a carefully selected sample of lemons indicated that the techniques used in the present work are capable of good precision. In particular, control juices extracted from this lot of fruit on two separate occasions had modal particle diameters differing by less than one percent, and width estimates taken from size distributions agreed within two percent.

In the course of examining lemons from several groves, it was found that fresh juices varied substantially in turbidity: 1.6 fold; in volume of particles exceeding 0.8  $\mu\text{m}$  diameter: 1.7 fold; in modal particle diameter: 2.3 fold; and in width of particle size distribution: 3.3 fold.

On the basis of the present work, which represents a moderately broad sampling of fresh, unpasteurized juices, it may be concluded that (1) fresh lemon juices differ markedly in the nature of their particle size distributions and (2) broadening of particle size distributions evidently occurs with advancing fruit maturation.

The properties of a commercial lemon juice concentrate were compared with averages obtained from a variety of fresh juices. The concentrate, as reconstituted with distilled, deionized water,

had 2.6 times the turbidity index of fresh juice. The volume of particles exceeding  $0.8\text{ }\mu\text{m}$  effective diameter was about forty percent of the average for fresh juice. Modal particle diameter was about half that of the fresh juices, and the particle size distribution had a width-height ratio that was about three percent of the value for fresh juice from non-senescent lemons.

Because of readily discernable differences between the clouds of concentrates and fresh lemon juices, it was natural to expect to find substantial differences in particle properties. The work completed underscores this expectation, but, in addition, it demonstrates the possibility of increased understanding of cloud properties via enhanced ability to quantitate particle characteristics.

In the juices examined, it is evident that a complex group of causes underlies the optical properties. The present line of work reveals some aspects of the causal links.



## DEVELOPMENTS IN CITRUS METHODOLOGIES

Robert E. Berry

Citrus and Subtropical Products Laboratories  
Winter Haven, Florida

Improved methods for determination of strength and quality of aqueous citrus essences, measurement of temperature abuse through a chemical index and improved determinations of naringin and limonin forestablishing an index of bitterness in grapefruit juice, are among the methodology developments at the Citrus and Subtropical Products Laboratory, Winter Haven, Florida, over the past year. The principal method for evaluating citrus essences has traditionally been the determination of chemical oxygen demand (COD). In this use, this method has many faults, principally because it measures components which comprise a high proportion of the organics of essence but do not contribute a proportionate influence on flavor. Nevertheless, because of its wide use the method was developed further, and improved by extending the range and increasing the accuracy. The use of silver sulfate catalyst was also shown to improve sensitivity, particularly when extremely dilute solutions are used. A new method for determining relative aqueous essence strength is based on a rapid titration method similar to the AOAC bromate titration for estimating recoverable oil in citrus juices. This method has been adapted for estimating total organic flavor constituents of aqueous citrus essences. It excludes the relatively large quantities of ethanol and methanol as well as the greatly fluctuating acetaldehyde which often makes COD determinations of essences misleading. Titration results gave good correlation with a direct gas chromatographic method and the complete titration requires less than five minutes. It has proven very satisfactory for determining relative strengths of essences produced by a given process.

A recently developed method capable of detecting furfural at levels as low as 5 ppb may provide a simple analysis which would function as an index of storage experience. Using this method, furfural was found to indicate temperature abuse in single strength orange and grapefruit juice packed in cans and glass at five different temperatures. Furfural level correlated closely with flavor change, although considering the flavor threshold, furfural itself probably is not responsible for the flavor change. Organoleptic studies indicate that detectable flavor changes can be predicted from changes in furfural level. In single strength orange juice for example, when furfural exceeded 50 ppb tasters could differentiate temperature abused juice at a 99% confidence level.

Further developments of tlc determinations on limonin and naringin now make it possible to use untreated juice applied directly to commercially available plates and separate naringin from its tasteless isomer, 7- $\beta$ -rutinoside of naringenin as well as limonin. For the naringin determination the spots may be eluted and determined colorimetrically through a modified Davis test, or they may be estimated by visually comparing with standard spots applied to the plate as with the limonin procedure. By a simple analytical approach it can easily be determined that limonin or naringin content is less than a given level, or within a predetermined range. Although these methods are not extremely precise, they easily provide the approximate estimations of these compounds to the degree which would normally be required in a quality control laboratory and as many as twenty determinations can be made in about two to three hours. All of these developed procedures are suitable for quality control application.

APPLICATION OF IMMUNE ASSAY METHODS TO  
PLANT BIOCHEMISTRY AND CITRUS TECHNOLOGY

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Pasadena, California

and

Stanley J. Gross  
School of Medicine  
University of California, Los Angeles

The use of antibody binding as a method for analysis of small molecules is a very recent development, but it has already found wide application in the assay of biologically important compounds in body fluids. The main advantages of this method are high specificity and sensitivity. The specificity inherent in antibodies often allows immune assays to be run without preliminary extraction and separation steps, thus saving much time.

Compounds of relatively low molecular weight are not antigenic; that is, they do not stimulate the formation of antibodies. However, if such a compound is chemically bound to a protein and the resulting conjugate is injected into an animal, antibodies are produced. These antibodies will then recognize (i.e., bind) the original small molecule. The specificity of an antibody is largely determined by the method used to couple the small molecule to protein. If, as is usually most convenient, one of the functional groups is used for this purpose, the resulting antibody will not recognize this site, and it may also bind structurally related compounds. For maximum specificity, a new functional group should be introduced into the molecule for coupling to protein.

The immune assay method involves competition between two chemical species for binding to an antibody. One of these is the compound to be assayed, and the other is a derivative of it which is amenable to instrumental analysis. Usually a radioactively labelled derivative is chosen; in such a case the antibody complex is separated physically from unbound material and its radioactivity counted. The amount of radioactivity is inversely proportionate to the concentration of the compound to be assayed; the exact value of the latter can then be read from a standard curve. Concentrations as low as  $10^{-12}$  molar can readily be determined by this method. Separation of the antibody complex may not be necessary if binding changes a measurable property of the derivative. For instance, a fluorescent derivative may emit much more strongly when bound to an antibody, and the increase in fluorescence can then be used as the basis for the assay.



Applications of immune assays to the analysis of plant material have been almost nil to date, but the method should be equally successful in this field. We are presently attempting to develop an assay for the citrus bitter principle limonin in orange juice. A derivative of limonin was made, coupled to a protein, and the conjugate was injected into animals. Isolation of antibodies is now in progress, and the present status of this research will be discussed.

A NEW BACTERIAL LIMONOATE DEHYDROGENASE AND ITS POSSIBLE  
USE IN DEBITTERING CITRUS JUICES

Shin Hasegawa, V. P. Maier and L. C. Brewster  
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In dealing with the bitterness problem due to limonin in citrus juices, we have been engaged in a search for microbial enzymes which convert the citrus bitter principle limonin to nonbitter compounds. Last year at this meeting we reported the isolation from Arthrobacter globiformis of a limonoate dehydrogenase which catalyzes the conversion of limonoate to nonbitter 17-dehydrolimonoate, and demonstrated also the conversion of limonin to the nonbitter compound in orange juices at pHs higher than 5.5 with this enzyme. A continuous survey of microorganisms resulted in the isolation of a new bacterium which metabolizes limonoate through two pathways: one via deoxylimonin and the other through 17-dehydrolimonoate.

When grown on a limonoate medium, this organism produced exocellularly a trace amount of deoxylimonin and substantial amounts of deoxylimononic acid in the medium. But unlike A. globiformis, no 17-dehydrolimonoate was produced in the growing medium. Analyses of cell-free extracts showed, however, the presence of activity of a limonoate dehydrogenase which was quite different from the dehydrogenase of A. globiformis. Therefore, this new dehydrogenase has been isolated, its properties characterized and its effectiveness in orange juice tested.

The enzyme was purified approximately 63 fold over the crude extract by ammonium sulfate precipitation followed by two columns of DEAE cellulose. The major differences in characteristics between this enzyme and the dehydrogenase of A. globiformis are that this enzyme has its optimal activity at pH 8.0 and has much wider pH activity range, that this enzyme takes both NAD and NADP as a cofactor whereas the dehydrogenase of A. globiformis takes only NAD, and that this enzyme is poorly retained on the DEAE cellulose column while the enzyme of A. globiformis is well retained.

Investigation of the possible use of this enzyme in a debittering process for citrus juices is underway. Preliminary tests show that in reconstituted navel orange juice adjusted to the optimum pH of the enzyme, sufficient limonin is converted to 17-dehydrolimonoate to reduce the limonin concentration of the juice to below the bitterness threshold. Activity was also good in juice at pH 3.5 provided that the D-ring of limonin was open. Factors relating to the production of the enzyme are under study.

The survey of limonin degrading microorganisms is continuing and another enzyme which catalyzes the conversion of limonin to a non-bitter product (deoxylimonin) is being isolated.

## FACTORS AFFECTING SENSORY THRESHOLDS OF LIMONIN AND NARINGIN

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and

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Fruit and Vegetable Chemistry Laboratory  
Pasadena, California

During the past few years there has been an increased awareness of limonin induced bitterness in orange juice and the traditional bitterness in grapefruit juices primarily caused by naringin. Reduction of limonin bitterness in orange juice by altering metabolic processes and by enzymatic treatment was reported at last year's conference. The objective of debittering efforts is to reduce the concentration of the bittering substances to acceptable levels. The ideal solution of the bitterness problem in orange juice would be reduction of limonin concentration to a point where even the most sensitive person would not be aware of its presence. In the case of grapefruit juice the ideal solution would be reduction of the combined bitterness of limonin and naringin to acceptable levels. This brings up the question of the minimum concentrations of these bittering substances that are perceived, both alone and when mixed, by human subjects, and the effect that various juice components have on these minimum detectable levels or threshold concentrations. This study was undertaken to answer this question.

Thresholds were determined for pure limonin and naringin in triple-distilled water and in the presence of acid, sugars, and model systems employing a combination of these ingredients. The interaction of limonin and naringin at sub-threshold concentrations was also determined in water. A well trained and experienced panel of 23-27 persons was used for the threshold measurements. The tests were conducted in individual booths at a temperature of  $74 \pm 2^\circ\text{F}$  and 50% R.H. Each judge received three pairs of samples at each session and the task required selection of the bitter sample in each pair. The concentration of bitter substance was increased by a factor of 2 from the lowest to highest concentration. The resulting sensory data was analyzed by rigorous procedures that gave mean panel thresholds and 95% confidence intervals and individual thresholds. The mean panel thresholds gave consistent results for limonin and naringin even when replicate determinations were made months apart (Table 1).



Table 1.--Thresholds of limonin and naringin in water solution

Compound	Date	Judgments	Mean	95% Confidence Interval	
			Threshold (ppm)	Lower limit	Upper limit
Limonin	9/70	300	1.0	0.75	1.34
Limonin	2/71	280	0.95	0.67	1.34
Naringin	9/70	256	20	15.5	25.8
Naringin	11/71	180	21	17.0	26.0

This data gives a fair degree of confidence that a given threshold value can be reproduced (within the confidence limits) with a panel of this size, provided a sufficient number of judgments are obtained under carefully controlled conditions.

For juices containing both limonin and naringin it is important to know whether the presence of both compounds cause interactions which would increase, decrease or not affect bitterness of the mixture. Mixtures of naringin and limonin in ratios ranging from 1 to 1 to 50 to 1 indicate that the effect of these two substances on bitterness perception is additive rather than synergistic or suppressive. Half the threshold concentration of each compound when mixed causes statistically significant ( $P=0.05$ ) perception of bitterness. This additivity was demonstrated for subthreshold concentrations of the bitter substances and may not be strictly true at much higher suprathreshold levels.

The effect of various pure compounds in distilled water on the thresholds of limonin and naringin was studied. Sucrose raised the bitterness thresholds of limonin and naringin in water somewhat. On the other hand, the effect of pH was very pronounced. For example, the limonin threshold ranged from 1.0 ppm at pH 6.5 to 12 ppm at pH 3.5. At a constant pH of 3.5, the limonin threshold varied from 8 to 12 ppm at a total acidity of 0.6 to 1.2% citric acid, respectively. The effect on bitterness threshold of adding sugars to acid solutions of limonin is a complex function of pH. At low pH the presence of sugars decreased the bitterness threshold substantially whereas at higher pH the reverse occurs.

These results will be discussed and compared with data obtained from other tests in which reconstituted orange concentrate (rather than water) was used as the liquid medium.

## COLOR STUDIES ON TEXAS ORANGE JUICE USING THE CITRUS COLORIMETER

Bruce J. Lime and Robert R. Cruse  
Food Crops Utilization Research Laboratory  
Weslaco, Texas

The Citrus Colorimeter, measuring red and yellow parameters in orange juice and processed orange products, has been accepted as an official method of color determination by the Florida Department of Agriculture after several years evaluation. The wide acceptance of the instrument in Florida suggests that it may be adopted in Texas for color measurement of citrus products. This study was undertaken to compare color values obtained by visual methods using the MacBeth Examolite, official with the Consumer and Marketing Service, USDA, and color values obtained from readings on a Model D45 Hunterlab Citrus Colorimeter, on Texas orange juice. Visual color scores were obtained by converting tube numbers to points as described in the U.S. Standards for Grades of Frozen Concentrated Orange Juice, where tube #5 equals 36 points (minimum required for Grade A) and tube #2 equals 40 points. Colorimeter scores were obtained by the formula:  $\text{Score} = 22.510 + 0.165 \text{ CR} + 0.111 \text{ CY}$ . Scores were taken on Hamlin, Marrs and Valencia orange juices, and on commercial samples graded by the Consumer and Marketing Service.

Fifty-one observations were made on Hamlin orange juice over a 4-1/2 month period. The average visual score was 35.2, while the average colorimeter score was 35.8. For the same individual samples, colorimeter scores ranged from 2.4 points higher to 1.8 points lower than the visual scores. Marrs orange juice was sampled over the same period; 52 observations were made. The average visual score was 36.2, while the colorimeter scores averaged 37.6. Individual differences ranged from +3.6 to -1.0 between colorimeter and visual scores.

Valencia oranges were sampled over a 4 month period; 45 observations were made. All Valencia samples received a visual color score of 39, while the average colorimeter score was 39.5. Individual differences between colorimeter and visual scores ranged from +2.8 to -1.0.

Forty-three samples graded by Consumer and Marketing Service were scored for color from Citrus Colorimeter readings. The average visual was 37.3; the average instrument score, 37.5; however, individual differences between instrument and visual scores varied from +1.9 to -2.8.

Color scores calculated from instrument readings would have raised the color values of 4 Hamlin, 6 Marrs and 2 commercial samples to the minimum required for Grade A Frozen Concentrated Orange Juice. One Hamlin and 2 commercial samples would have had lowered color values from colorimeter scores below the 36 point minimum for Grade A.

DEVELOPMENT OF NEW CAROTENOID INDUCING AGENTS  
FOR COLOR AND PROVITAMIN A ENHANCEMENT IN CITRUS\*

H. Yokoyama, W. J. Hsu and S. M. Poling  
Fruit and Vegetable Chemistry Laboratory  
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As part of our research program on the improvement of nutritional value (provitamin A) and natural color of oranges and other citrus fruits, we have been studying the chemical and/or biochemical factors involved in the regulation of carotenoid pigment formation in citrus fruits. With an understanding of the factors involved in the regulatory mechanism, carotenoid formation in citrus could conceivably be regulated or controlled to induce the development of those specific naturally occurring citrus carotenoids that are most desirable because of their intense color, high stability and provitamin A properties. Relating to this, previously at this meeting we reported on a chemical compound CPTA [2-(4-chlorophenylthio)triethylamine hydrochloride] which is an effective regulator of the carotenoid color formation in citrus fruits. The work on CPTA, as indicated in our earlier reports, was carried out in collaboration with Dr. Charles Coggins of the University of California, Riverside.

In our continuing studies we have directed our efforts toward learning how to improve the formation and accumulation of the provitamin A carotenoids in oranges and at the same time improve the color of the fruit. In line with these efforts at this laboratory, we have synthesized a number of new and biologically active agents. These compounds can be easily and cheaply synthesized from readily available low cost starting materials. All of the compounds are effective in enhancing the color and provitamin A content of oranges and other citrus fruits. They cause a shift in the type of carotenoid produced. A general pattern of large accumulation of lycopene with concomitant increase in synthesis of the provitamin A  $\gamma$ -carotene is observed in oranges and other citrus fruits. Differences in responses to different levels of concentration of the compounds are noted. The pattern of large accumulation of the acyclic lycopene accompanied by similar accumulation of the monocyclic provitamin  $\gamma$ -carotene is strongly indicative of the multifunctional nature of these newer carotenoid inducing compounds. We believe that further investigations could lead to the isolation of a naturally occurring agent that specifically controls the formation of the desired citrus carotenoids.

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\*This research was supported in part by the Citrus Advisory Board, Los Angeles, California.



A substantial advance was made in improving the method of application of the carotenoid inducing compounds to the citrus fruit. Previously on short immersion (30 seconds), treated fruit frequently developed a blotchy appearance due to non-uniform color formation. It required a much longer (5 minutes or longer) immersion to obtain a much more uniform response in color development. With the new method in which the compounds are utilized in a different form, the citrus fruit develops a much more uniform color and immersion time is shortened greatly.

The nature of the new compounds and the factors bringing about the desirable changes in such citrus fruits as oranges will be discussed in detail.

A NEW STATISTICAL APPROACH TO THE EVALUATION OF  
LEMON JUICE\*

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Fruit and Vegetable Chemistry Laboratory  
Pasadena, California

and

Bruce E. Mackey  
Biometrical Services, Western Regional Research Laboratory  
Berkeley, California

The data from 289 fresh and commercial samples of lemon juice from California, Arizona, Florida, and Italy collected over the period 1959 to 1969 were reexamined with respect to detecting citric acid adulteration. In order to make the parameters independent of dilution, ratios of the various constituents were selected rather than concentrations.

The ratios of amino acids to total phenolics (AA/TP) and l-malic acid to total phenolics (MA/TP) would be independent of dilution or added citric acid, whereas the citric acid-total phenolics ratio (CA/TP) is still independent of dilution but would reflect added citric acid. It was determined that AA/TP and MA/TP were highly correlated with CA/TP. A multiple regression approach was used to predict CA/TP as a function of AA/TP and MA/TP. The coefficient of determination ( $R^2$ ) was 0.918.

The absolute difference between the measured and predicted CA/TP was proportional to the measured value. On the other hand, measured CA/TP divided by predicted CA/TP was symmetrically distributed with a mean value of 1.00 and a standard deviation of 0.112. The new function was shown not to differ significantly from the normal distribution curve. Statistical criteria have been established to determine the number of samples required to detect any level of citric acid addition at any probability of rejecting authentic and adulterated samples. For example, with five samples a 12, 14, 18 and 22% adulteration could be detected 90% of the time at significance levels of 0.1, 0.05, 0.01 and 0.001, respectively.

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\*This research was supported in part by the Lemon Products Technical Committee, Los Angeles, California.

DETECTION AND OCCURRENCE OF DIHYDROCHALCONE GLYCOSIDES. NEW DERIVATIVES  
OF DIHYDROCHALCONES

R. M. Horowitz, Bruno Gentili, D. L. Dreyer and Wynn Raymond  
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Pasadena, California

It was reported briefly at an earlier meeting that dihydrochalcones obtained from naturally occurring citrus flavanones can be detected by reducing them with sodium borohydride followed by treatment with dicyanodichlorobenzoquinone (DDQ) and acid. Dihydrochalcones respond by giving a vivid purple or mauve color, while other classes of flavonoids give either no color or a brownish-pink. Evidence from model compounds suggests that the purple species is a 1,3-diaxially allylic carbonium ion. The method has proved useful in the chromatographic analysis of large scale preparations of neohesperidin dihydrochalcone and in monitoring the synthesis of new dihydrochalcone derivatives.

Another application is as follows: One of us (W.R.) noticed that the thin albedo portion of kumquats (Fortunella margarita) has a characteristic, non-sugar-like sweetness and suggested that this could conceivably be due to the presence of a dihydrochalcone. To test this possibility we extracted a quantity of kumquat peel and examined the extract by thin-layer and paper chromatography. Application of the borohydride-DDQ reagent to the chromatograms showed the presence of three positive-reacting compounds. These compounds have proven to be exceedingly difficult to isolate in pure form. One of them, however, has now been obtained in very low yield as a homogeneous, non-crystalline solid. The UV, IR and NMR spectra of this material, together with the fact that it gives a positive reaction with the borohydride-DDQ reagent, make it appear reasonably certain that it is a dihydrochalcone glycoside of complex structure. It is not known yet whether this compound or either of the other positive-reacting ones is responsible for the sweet taste of the peel. Dihydrochalcones have not been reported previously in citrus fruits or other edible plant products. The probable occurrence of this class of compound in citrus should have obvious implications with regard to the acceptability of certain ones as sweeteners.

Several sweet new glycosides of hesperetin dihydrochalcone have been synthesized. Since the starting material for the aglycone portion of these compounds is hesperidin, this work provides another potential use for this most abundant and available of citrus flavonoids. These compounds and some related ones reported in the recent literature will be discussed.



LIST OF PUBLICATIONS AND PATENTS\*

WESTERN REGION

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THE CALIFORNIA LEMON JUICE INDUSTRY: ITS TECHNOLOGICAL STATUS.

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